FIG. 1

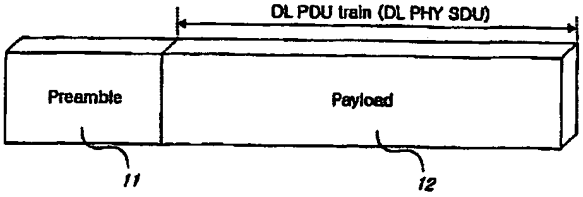
DL PDU train (DL PHY SDU)
Preamble
Payload
11
12

FIG. 2

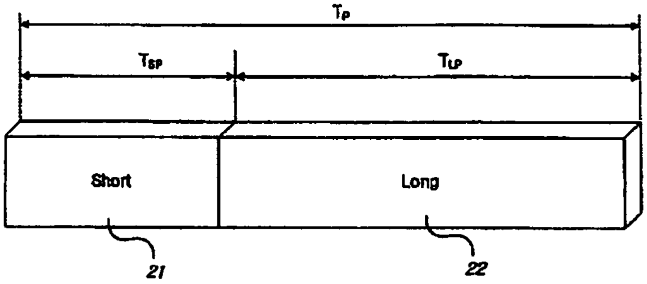
T_P
T_{SP}
T_{LP}
Short
Long
21
22

FIG. 3

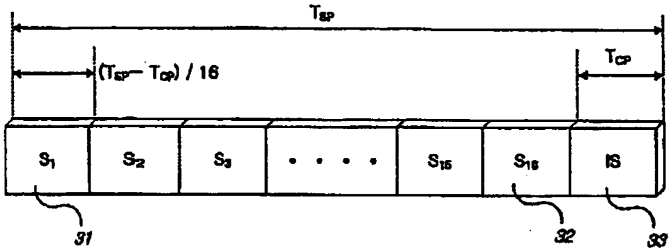
T_SP
(T_SP − T_CP) / 16
T_CP
S1
S2
S3
• • • • •
S15
S16
IS
31
32
33

FIG. 4

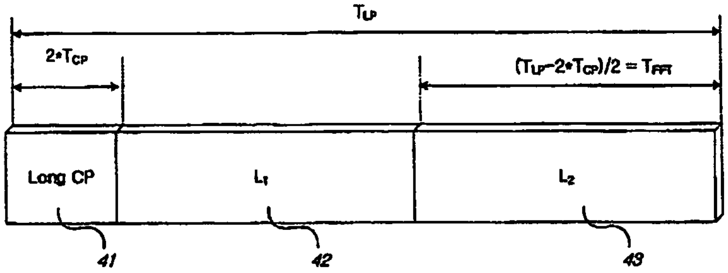
T_{LP}
$2*T_{CP}$
$(T_{LP}-2*T_{CP})/2 = T_{FFT}$
Long CP
L_1
L_2
41
42
43

FIG. 5

parameter	value
T_P: PLCP Preamble Period	6.8μs (= $T_{SP}+T_{LP}$)
T_{CP} : Cycle prefix period	0.133μs (= T_U /16)
T_{SHORT} : Short training sequence period	2.27μs
T_{LONG} : Long training sequence period	4.53μs

FIG. 6

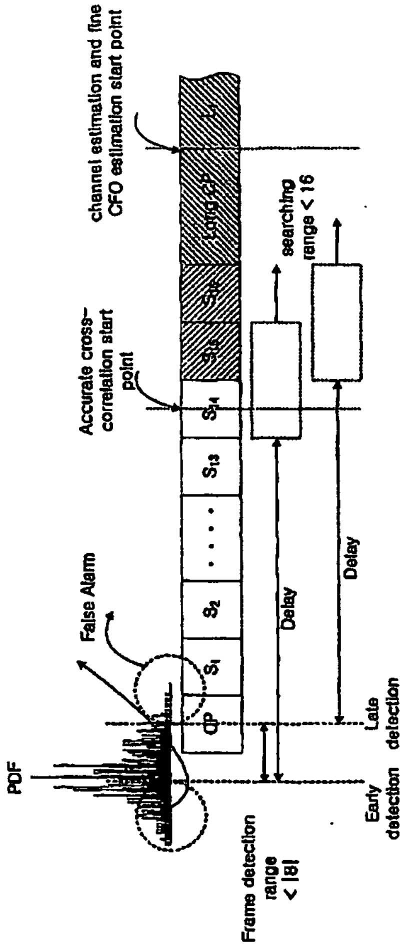
channel estimation and fine CFO estimation start point
Accurate cross-correlation start point
False Alarm
PDF
CP
S1
S2
....
S13
S14
S15
S16
Long CP
L1
searching range < 16
Delay
Delay
Late detection
Early detection
Frame detection range < |8|

FIG. 7

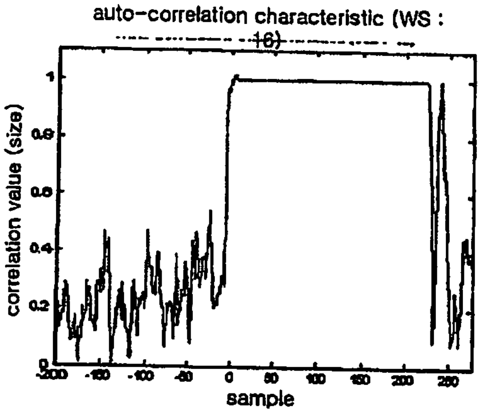
auto-correlation characteristic (WS : 16)
correlation value (size)
1
0.8
0.6
0.4
0.2
0
-200
-150
-100
-50
0
50
100
150
200
250
sample

FIG. 8

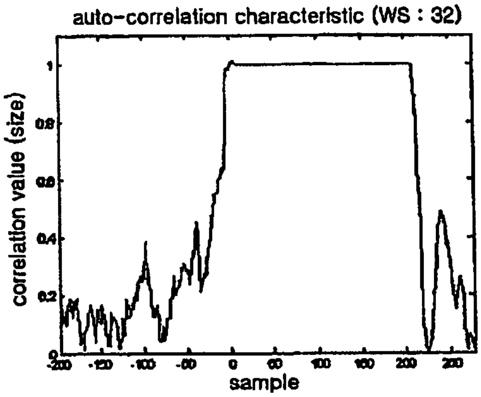
auto-correlation characteristic (WS : 32)
correlation value (size)
0
0.2
0.4
0.6
0.8
1
-200
-150
-100
-50
0
50
100
150
200
250
sample

FIG. 9

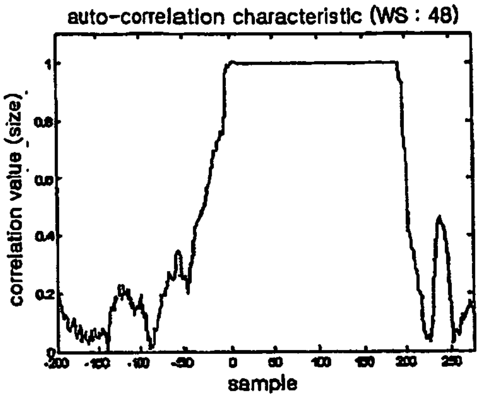
auto-correlation characteristic (WS : 48)
correlation value (size)
1
0.8
0.6
0.4
0.2
0
-200
-150
-100
-50
0
50
100
150
200
250
sample

FIG. 10

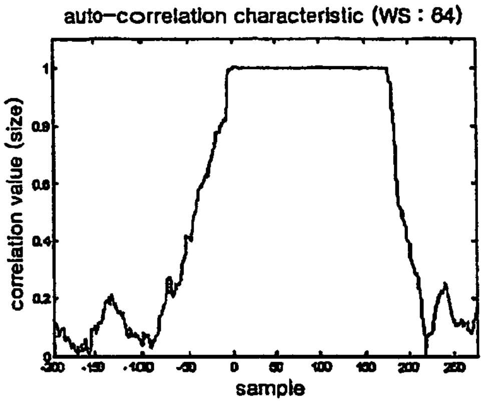
auto–correlation characteristic (WS : 64)
correlation value (size)
1
0.8
0.6
0.4
0.2
0
-200
-150
-100
-50
0
50
100
150
200
250
sample

FIG. 11

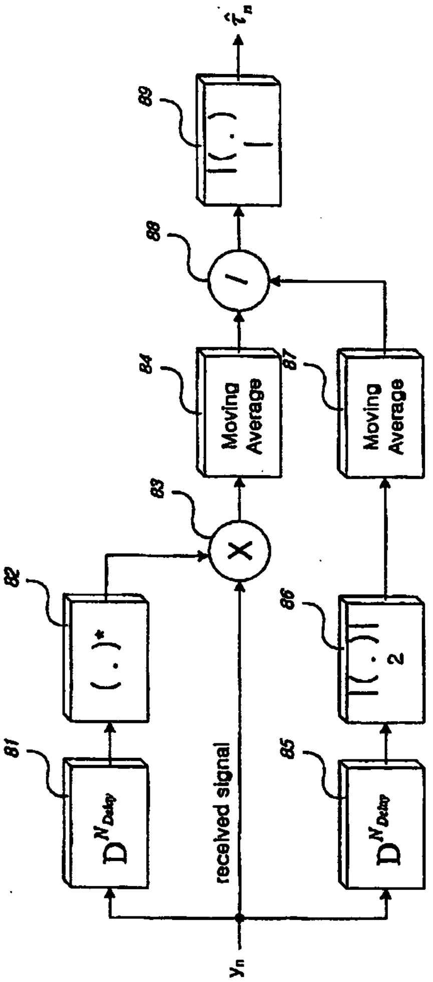
y_n
received signal
81
$D^{N_{Delay}}$
82
$(.)^*$
83
X
84
Moving Average
85
$D^{N_{Delay}}$
86
$|(.)|^2$
87
Moving Average
88
/
89
$|(.)|$
$\hat{\tau}_n$

FIG. 12

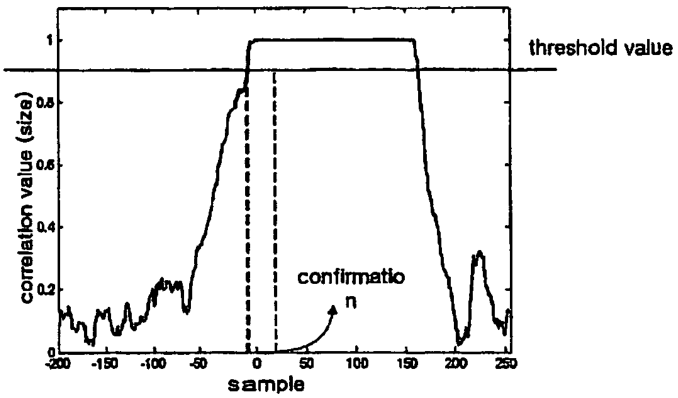
threshold value
correlation value (size)
1
0.8
0.6
0.4
0.2
0
-200
-150
-100
-50
0
50
100
150
200
250
sample
confirmatio
n

FIG. 13

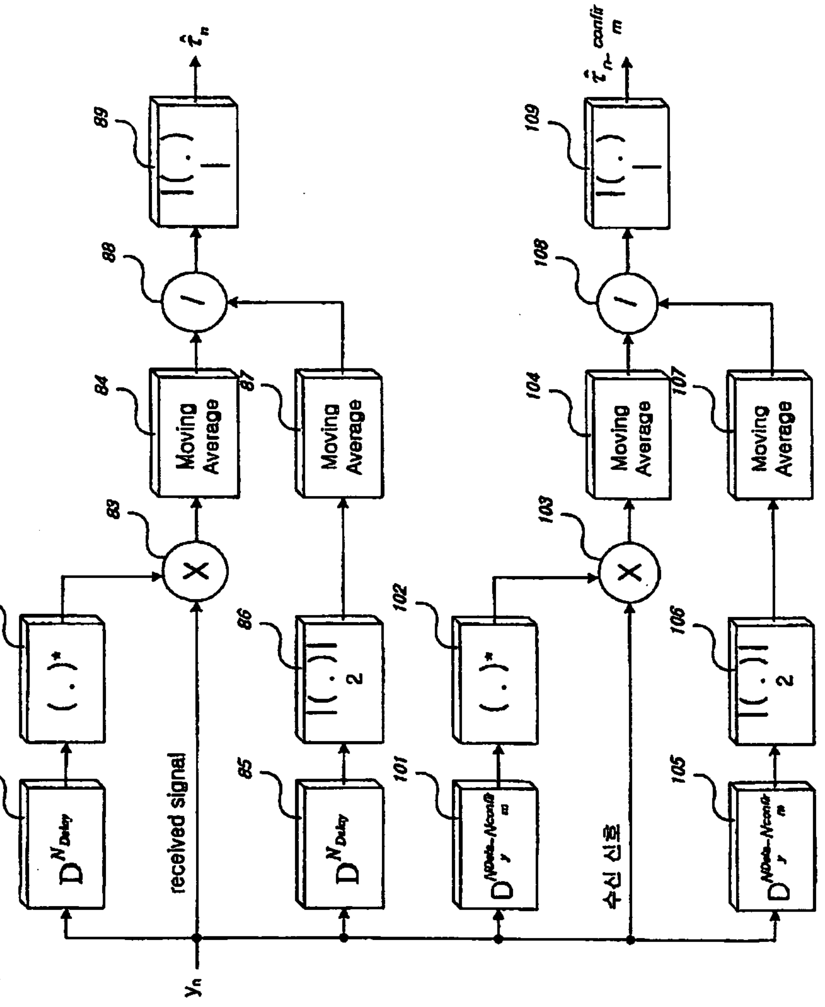
y_n
received signal
수신 신호
81
$D^{N_{Delay}}$
82
$(\cdot)^*$
83
$\times$
84
Moving Average
85
$D^{N_{Delay}}$
86
$|(\cdot)|^2$
87
Moving Average
88
/
89
$|(\cdot)|$
$\hat{\tau}_n$
101
$D^{N_{Delay}-N_{confirm}}$
102
$(\cdot)^*$
103
$\times$
104
Moving Average
105
$D^{N_{Delay}-N_{confirm}}$
106
$|(\cdot)|^2$
107
Moving Average
108
/
109
$|(\cdot)|$
$\hat{\tau}_{n-confirm}$

FIG. 14

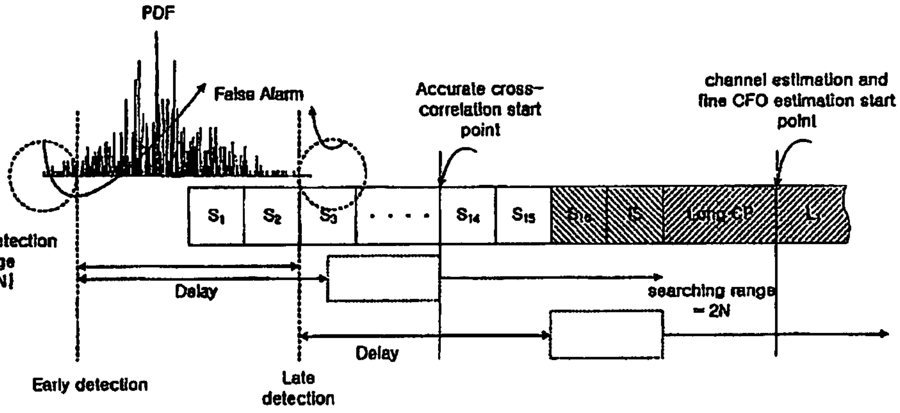
PDF
False Alarm
Accurate cross-correlation start point
channel estimation and fine CFO estimation start point
S_1
S_2
S_3
. . . .
S_{14}
S_{15}
S_{16}
IS
Long CP
L_1
Frame detection range < |N|
Delay
searching range = 2N
Delay
Early detection
Late detection

FIG. 15

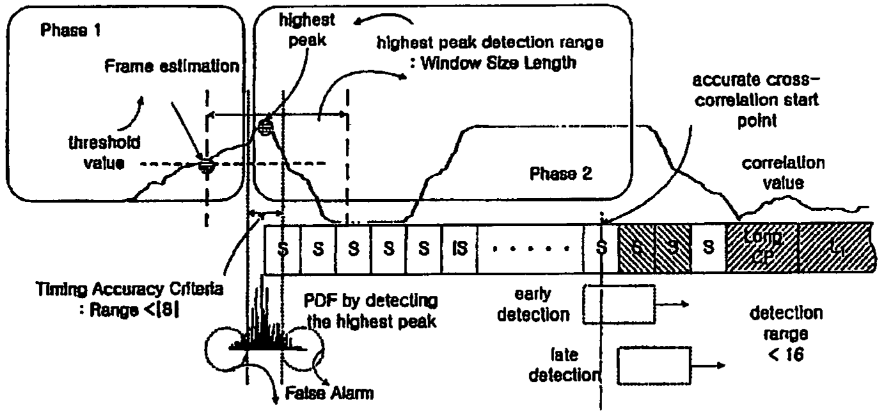
Phase 1
Frame estimation
threshold value
highest peak
highest peak detection range
: Window Size Length
Phase 2
accurate cross-correlation start point
correlation value
S
S
S
S
S
IS
· · · · ·
S
S
S
S
Long CP
L1
Timing Accuracy Criteria
: Range <|8|
PDF by detecting the highest peak
False Alarm
early detection
late detection
detection range
< 16

FIG. 16

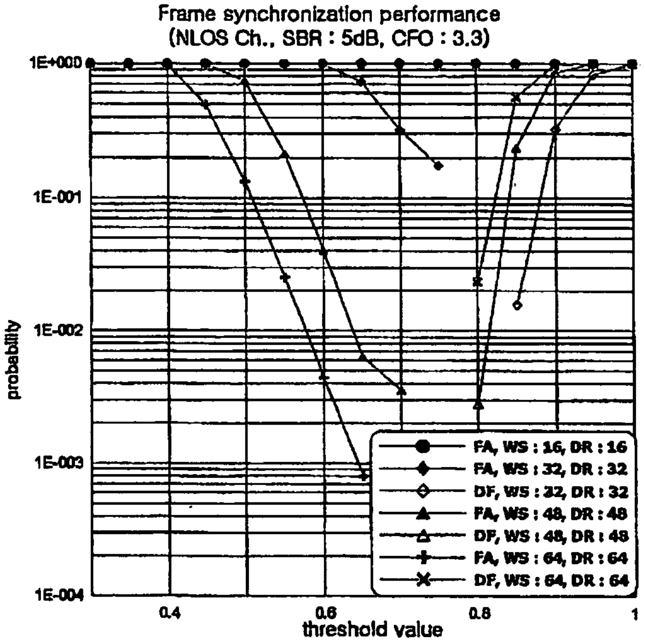
Frame synchronization performance
(NLOS Ch., SBR : 5dB, CFO : 3.3)
1E+000
1E-001
1E-002
1E-003
1E-004
probability
0.4
0.6
0.8
1
threshold value
FA, WS : 16, DR : 16
FA, WS : 32, DR : 32
DF, WS : 32, DR : 32
FA, WS : 48, DR : 48
DF, WS : 48, DR : 48
FA, WS : 64, DR : 64
DF, WS : 64, DR : 64

FIG. 17

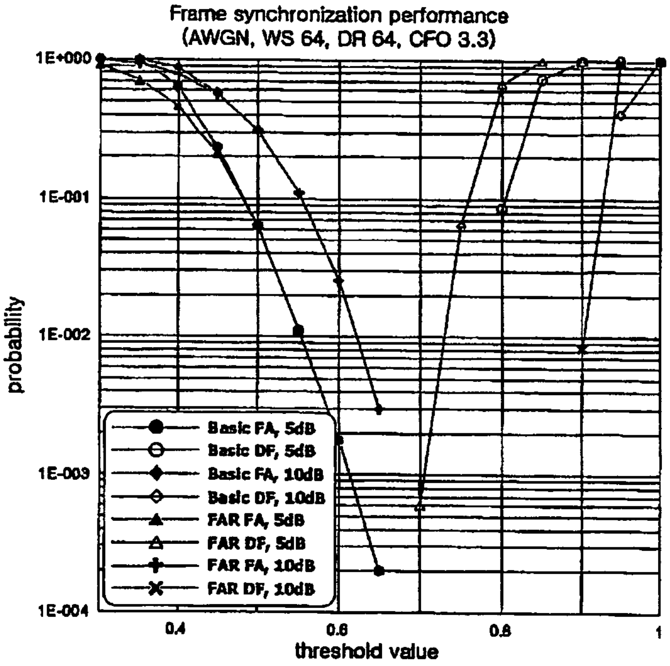
Frame synchronization performance
(AWGN, WS 64, DR 64, CFO 3.3)
probability
1E+000
1E-001
1E-002
1E-003
1E-004
0.4
0.6
0.8
1
threshold value
Basic FA, 5dB
Basic DF, 5dB
Basic FA, 10dB
Basic DF, 10dB
FAR FA, 5dB
FAR DF, 5dB
FAR FA, 10dB
FAR DF, 10dB

FIG. 18

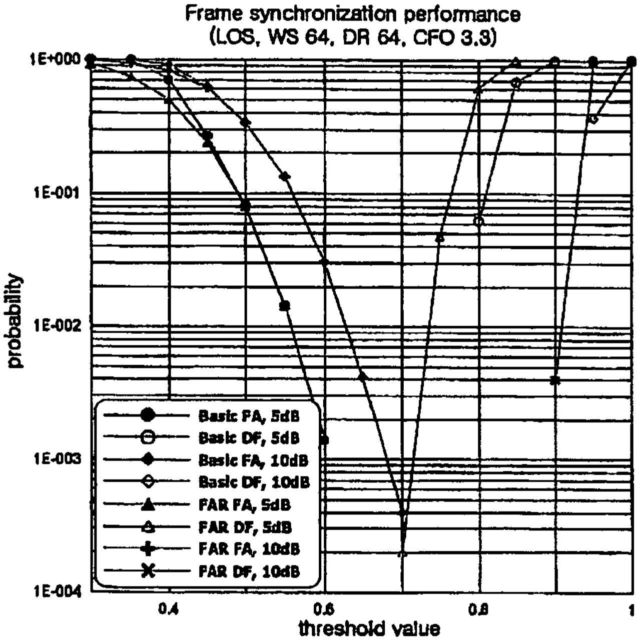
Frame synchronization performance
(LOS, WS 64, DR 64, CFO 3.3)
1E+000
1E-001
1E-002
1E-003
1E-004
probability
0.4
0.6
0.8
1
threshold value
Basic FA, 5dB
Basic DF, 5dB
Basic FA, 10dB
Basic DF, 10dB
FAR FA, 5dB
FAR DF, 5dB
FAR FA, 10dB
FAR DF, 10dB

FIG. 19

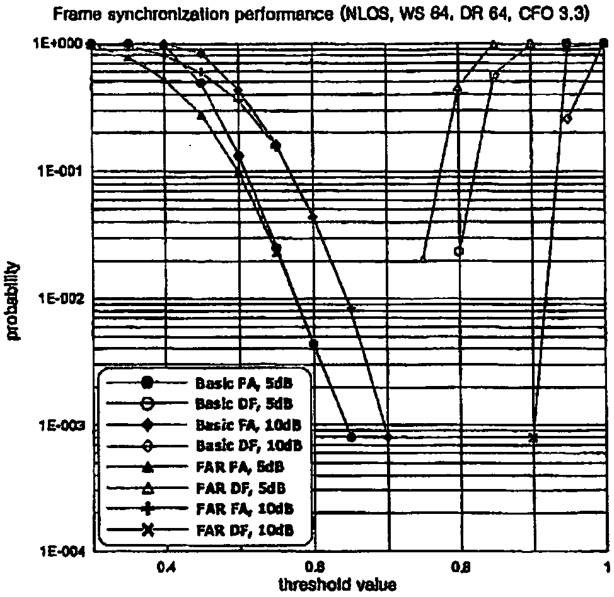
Frame synchronization performance (NLOS, WS 64, DR 64, CFO 3.3)
probability
1E+000
1E-001
1E-002
1E-003
1E-004
0.4
0.6
0.8
1
threshold value
Basic FA, 5dB
Basic DF, 5dB
Basic FA, 10dB
Basic DF, 10dB
FAR FA, 5dB
FAR DF, 5dB
FAR FA, 10dB
FAR DF, 10dB

FIG. 20

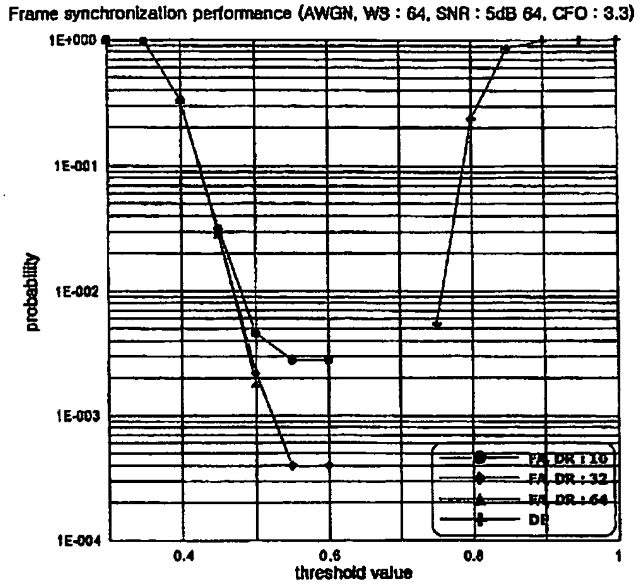
Frame synchronization performance (AWGN, WS : 64, SNR : 5dB 64, CFO : 3.3)
1E+000
1E-001
1E-002
1E-003
1E-004
probability
0.4
0.6
0.8
1
threshold value
FA, DR : 16
FA, DR : 32
FA, DR : 64
DR

FIG. 21

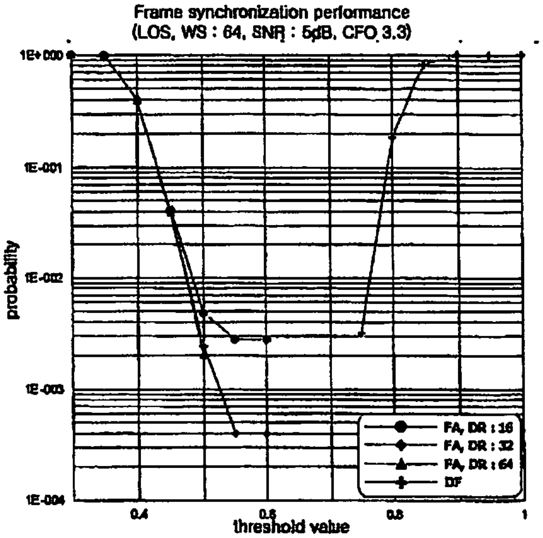
Frame synchronization performance
(LOS, WS : 64, SNR : 5dB, CFO 3.3)
1E+000
1E-001
1E-002
1E-003
1E-004
probability
0.4
0.6
0.8
1
threshold value
FA, DR : 16
FA, DR : 32
FA, DR : 64
DF

FIG. 22

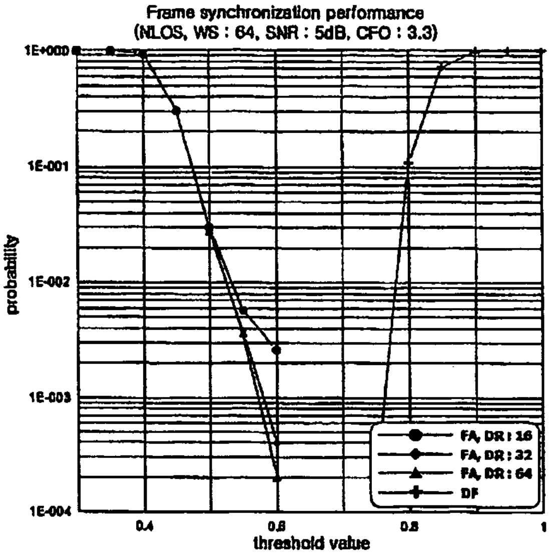
Frame synchronization performance
(NLOS, WS : 64, SNR : 5dB, CFO : 3.3)
1E+000
1E-001
1E-002
1E-003
1E-004
probability
0.4
0.6
0.8
1
threshold value
FA, DR : 16
FA, DR : 32
FA, DR : 64
DF

FIG. 23

channel	method 1			method 2 (detection range)		
	Threshold	FA	DF	Threshold	FA	DF
AWGN	0.65	$2.000*10^{-4}$	$<2.000*10^{-4}$	0.60	$2.800*10^{-3}$	$<2.000*10^{-4}$
LOS		$<2.000*10^{-4}$	$<2.000*10^{-4}$		$2.800*10^{-3}$	$<2.000*10^{-4}$
NLOS		$8.000*10^{-4}$	$<2.000*10^{-4}$		$2.600*10^{-3}$	$<2.000*10^{-4}$

FIG. 24

channel	method 1			method 2 (detection range)		
	Threshold	FA	DF	Threshold	FA	DF
AWGN	0.65	$2.000*10^{-4}$	$<2.000*10^{-4}$	0.60	$4.000*10^{-4}$	$<2.000*10^{-4}$
LOS		$<2.000*10^{-4}$	$<2.000*10^{-4}$		$4.000*10^{-4}$	$<2.000*10^{-4}$
NLOS		$8.000*10^{-4}$	$<2.000*10^{-4}$		$4.000*10^{-4}$	$<2.000*10^{-4}$